Research Report 1477

# User Acceptance and Field Implementation of Decision Support Systems

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This report documents the results of an invitational workshop on User Acceptance and Implementation of Military Decision Support Systems held at Fort Leavenworth on January 28-29, 1987. It was sponsored by the U.S. Army Research Institute, the Joint Services Working Group on Decision Aiding, and the U.S. Army Combined Arms Combat Developments Activity at Fort Leavenworth. Participants included 14 representatives from the military, government, and government contractors. The objectives of the workshop were to (1) identify a list of user acceptance problems and develop strategies for addressing each of them; (2) discuss problems associated with involving users in aid design and evaluation; and (3) make recommendations for addressing these user involvement problems. The report lists 22 user acceptance problems identified during the workshop and discusses the recommendations made by participants. They concluded that most of the recommendations that were made could best be accomplished through careful organizational management of the

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design and implementation of the system. Other general recommendations included early and on-going user involvement in aid design and evaluation, identification of the appropriate user for design and evaluation, common interface across aids and systems, training and education, an evolutionary development cycle, and organizational mechanisms for formally linking the user and builder. Suggestions were made for other organizational mechanisms that would facilitate user acceptance.

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# User Acceptance and Field Implementation of Decision Support Systems

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## FOREWORD

Each of the military services has made a commitment to developing and implementing automated information and decision support systems (DSS). However, successful transfer of this technology is ultimately contingent on users' acceptance and use of the technology.

This report presents a comprehensive overview of the problems in user acceptance from the viewpoints of both researchers and military personnel who have experience in aid design and implementation. The report should be useful to military DSS builders and developers in helping them to successfully transfer automation technology to the user.

The initiative for the Workshop on User Acceptance came from the Joint Services Working Group on Decision Aiding (JSWGDA), a subgroup of the Decision Aids subpanel of the Joint Directors of Laboratories Technology Panel for $C^3$. A major objective of the Working Group is to promote the exchange of information underlying advances in $C^2$ decision aiding and facilitate joint service research and activities in this area. The workshop is such a joint activity with representatives from the services participating.

The project was conducted under research task 1.4.4, Evaluating and Enhancing Command Staff Operations. It was cosponsored by the U.S. Army Research Institute, JSWGDA, and the Combined Arms Combat Developments Activity. The results of this report were briefed on July 7, 1987, to the Joint Services Working Group on Decision Aiding, various government contractors, and other personnel from the tri-services. The report will be used by the JSWGDA to identify areas for joint services research.

EDGAR M. JOHNSON
Technical Director

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This report would not have been possible without the contributions of the 14 workshop participants who generously shared their time, ideas, expertise, and experiences to explore the issues and develop the recommendations contained in this report. I am indebted to all of them. I would especially like to thank Dr. Wayne Zackery, Dr. Robert Mackie, and CPT Patrick Vye, who ably served as group discussion leaders.

I gratefully acknowledge the contributions of Dr. Stanley Halpin, MAJ Edward Sullivan, and Dr. Jon Fallesen, who assisted with the arrangements and provided valuable comments on the first draft of the report. Finally, my thanks go to Mrs. Karin Brightwell, whose secretarial assistance and skilled typing were invaluable to the conduct of the workshop and preparation of this report.

# USER ACCEPTANCE AND FIELD IMPLEMENTATION OF DECISION SUPPORT SYSTEMS

## EXECUTIVE SUMMARY

Requirement:

To identify the problems relating to the acceptance of military decision support systems (DSS) and to make recommendations for addressing each of these problems; to identify problems relating to involving the user in design and implementation and to make recommendations for addressing each of them; and to discuss mechanisms for field implementation that would enhance user acceptance.

Procedure:

The U.S. Army Research Institute, the Joint Services Working Group on Decision Aiding, and the U.S. Army Combined Arms Combat Developments Activity sponsored an invitational workshop to explore factors that affect user acceptance. Knowledgeable participants, with experience in the design, evaluation, and implementation of military DSS, as well as researchers in these areas, were identified and invited to the 2-day workshop. The 14 participants included representatives from the Army, Air Force, and government contractor community.

Participants were divided into two groups, each representing a mix of military, government employees, and government contractors. Each group independently discussed assigned topics relating to the workshop objectives.

Summaries of each subgroup's discussions were presented to the larger group and discussed in this forum. This report presents the material developed by this method.

Findings:

a. Twenty-two causes of problems of user acceptance were identified, and recommendations for addressing each were developed. Problems were categorized into those involving perceived lack of utility, difficulty using the system, and damage to the user.

b. General recommendations for addressing these problems included (1) early and ongoing involvement of the users in the development of requirements, in system design, and in development and implementation; (2) common user interface across aids and systems; (3) evolutionary design and development of aids; (4) education to alter erroneous perceptions and adequate training in the use of the system; (5) development of formal organizational links

between users, combat developers, and aid builders; and (6) use of adaptive design and rapid prototyping if they can be integrated into the materiel acquisition process.

c. Most of the recommendations in the report are best accomplished through careful organizational management of the design and implementation of the system.

Utilization of Findings:

The findings will be useful to the combat developers and builders tasked with designing, implementing, and fielding military decision support systems. The findings indicate that organizational mechanisms are needed to address many of the user acceptance problems that were identified.

USER ACCEPTANCE AND FIELD IMPLEMENTATION OF DECISION SUPPORT SYSTEMS

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# USER ACCEPTANCE AND FIELD IMPLEMENTATION OF DECISION SUPPORT SYSTEMS

## INTRODUCTION

The military services have made a commitment to the development and use of automated information and decision support systems. Given the enormous investment of resources in such technology, it is important to ensure its efficient transfer into the operational environment. However, there are documented cases of military technology innovations which have not achieved user acceptance and which have been subsequently misused and even rejected by users. It would be useful then, to be able to predict and control the factors that adversely affect user acceptance of such technologies. This report documents the results of a workshop that explored factors contributing to user non-acceptance and generated recommendations for controlling these factors.

The US Army Research Institute (ARI), the Combined Arms Combat Developments Activity (CACDA), and the Joint Services Working Group on Decision Aiding sponsored a Workshop to discuss factors that affect user acceptance. The objectives of the Workshop were (1) to explore the factors that affect user acceptance of military decision aids/support systems; (2) to develop solutions to user acceptance problems; and (3) to discuss mechanisms for field implementation that may enhance user acceptance. In order to accomplish these objectives, knowledgeable participants, who had experience with aid development and implementation or who had done research in user acceptance, were invited to the Workshop. This report summarizes the ideas and recommendations of the Workshop participants.

A number of definitions of the term "decision support systems" (DSS) have been advanced. For the Workshop, the term was defined as computer software that supports decision making. "Support" was defined very generally so that any aid or system that participants wanted to discuss would be included. As it is used here, "decision support systems" is a very broad term. It would include one simple program designed to aid one staff user in accomplishing one task as well as a complex multi-purpose integrated system which supports multiple users working multiple tasks, sharing information within or between battlefield functional areas. Some of the user acceptance issues will be the same regardless of the complexity or size of the aid, while other issues will be specific to certain types of aids. A goal of the workshop was to identify a comprehensive set of user acceptance issues, and defining DSS very broadly insures that the issues identified will be as comprehensive as possible. Throughout the report, as in the Workshop, "aid" and "DSS" were used interchangeably even though "DSS" is the more comprehensive term.

The material in the report is slanted toward the Army because of the make-up of the Workshop group. However, the recommendations are generally applicable because similar user acceptance problems exist in all three services.

## APPROACH

The workshop brought together 14 participants from ARI, CACDA, TRADOC[1] Analysis Command (TRAC), the Air Force Institute of Technology, US Army Signal Center and School, and several government contractors. (See Appendix A for a list of participants). Participants were divided into two groups each representing a mix of military, government employees, and government contractors. These groups were small enough to permit all to participate and the mix represented a diversity of perspectives, expertise, and experience.

Each group independently discussed the following topics:

1. Definition of the User.
2. Specific factors that affect user acceptance.
3. Strategies for addressing each of these factors.
4. Problems with involving users in the design and evaluation of automated systems.
5. Approaches for addressing user involvement problems.

Summaries of each subgroups' discussions were presented to the whole group and discussed again. The following report presents the material developed through this method. The material does not necessarily represent a consensus opinion, but represents majority or significant minority opinions.

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[1] Training and Doctrine Command

## DEFINING THE USER

Before we could discuss user acceptance, we needed to clarify who we mean by "the user". There can be many different types of users of the same aid, and these users can vary in a number of ways.

- There are different levels of users for different aspects of the aids:
    - End user or aid operator
    - Decision maker: commander and staff
    - Organizations

  In some instances these users can be the same person. For example, the G3 (i.e., the operations officer) could both interact physically with the aid and use the aid's output in his recommendations.

- Within each of these levels, individual users can differ. For example, they can be experienced or inexperienced, commander or staff, G2 (i.e., the intelligence officer) or G3. Table 1 presents variables on which users differ and which may influence the users' performance or acceptance of an aid.

- There can be "within-user" differences. That is, the same user can differ on a variable depending on the task, environment, or with the passage of time. For example, the experience level of the user will change the more he uses the system.

- Use of an aid may change the task structure or work flow so that the intended user may not end up being the actual user. For example, it may have been originally intended that a staff officer would physically interact with the aid upon instructions from a commander. However, in actual use the commander himself may interact with the aid to get the information he needs.

- Future aids will be part of larger integrated systems with multiple functions, users and environments. For example, Brigade Planner (Diaz & Smith, 1986), developed by TRAC, supports multiple tasks for different users. In the AirLand Battle Concept, synchronization is an important requirement for battle success. To accomplish this synchronization, automated systems of the future may have a common user interface to facilitate the sharing of information and battle management plans. The same system interface may be used by users from different functional areas and even different services.

Table 1

Individual Differences That May Affect Decision Making Performance

| |
|---|
| Demographic Characteristics |
| Age |
| Gender |
| Rank/Command Level |
| Education |
| Personality Characteristics |
| Decision Making Style |
| Cognitive Style |
| Learning Style |
| Risk Taking Propensity |
| Motivation |
| Locus of Control |
| Skills/Abilities |
| Task Expertise |
| Knowledge of Task Requirements |
| Skill/Experience with the System |
| Training |
| Spatial and Verbal Ability |
| Intelligence |
| Preferences |
| Goals |
| Preferences for Display Format |
| Preferred Sensory Modality |
| Preferred Communication Mode |

The same system can have many different types users. Acceptance by one user does not mean acceptance by all users. Different users have different types of user acceptance problems and different users are needed to evaluate different aspects of user acceptance.

The question "Who is the user?" has implications for other aspects of system development. Most aid decision and evaluation handbooks recommend that the intended users be employed to develop aid design requirements and be used to evaluate the aid. However, Workshop participants felt that the diversity of potential users is a major problem in the development of automated support systems. That is, which user should be selected for design and evaluation input? The user one selects will affect aid design and evaluation results. If different users produce markedly different design requirements and evaluation results, then this suggests that results obtained with one or two users are not generalizable to the whole population of potential users. This is a problem which is not being addressed sufficiently and often not even recognized as a problem. Designers and evaluators do not specify what characteristics the user must have who is to assist them and developers don't spend time selecting the proper user to send to the designer or evaluator.

## FACTORS THAT AFFECT USER ACCEPTANCE AND RECOMMENDATIONS FOR ADDRESSING THESE FACTORS

Workshop participants identified 22 factors that can adversely affect the user acceptance of an aid and they made recommendations for dealing with each factor. Table 2 presents a summary of the factors and recommendations. Not all of the participants agreed with each.

### Perceived Lack of Utility

Workshop participants thought that perceived utility was the most important factor in acceptance of the aid. If the system clearly supports improved decision making and meets user needs then other factors adverse to acceptance may be overridden. Perceived lack of utility has two major causes. The aid may indeed lack utility. This is discussed in items one through three below. On the other hand, if the aid does meet user needs, then the lack of user acceptance stems from erroneous perceptions of the aid. This is discussed in items four through thirteen.

1. The aid lacks utility.

Lack of utility in an aid can be a problem of requirements definition, and requirements definition is not an easy task. Users may not know what they need, or how to specify their needs; users may not agree on their needs; they are not good at predicting future needs; needs may change with the incorporation of the aid; or different users of the aid may have different needs.

It is not unusual for aid development to be driven by technology rather than requirements. Builders learn about a promising technology and look for potential applications of the technology. The aid is selected for development not because it fills a user need, but because it is an application of a technology the builder wants to use.

Recommendations: Clearly, there is a need for user involvement in requirements analysis. One approach to this problem is through adaptive design - where the Subject Matter Expert (SME) is the designer and does his own requirements specification. Another technique is rapid prototyping. Here a prototype of the aid is developed, tested by the users, rapidly modified, and tested again, etc. The rationale is that it is easier for a user to react to a concrete aid than to imagine what he needs. It is an "I know what I like when I see it" approach. One general problem with user involvement in rapid prototyping is that users are needed on an ongoing and long term basis. Another problem is related to the generalizability of design and evaluation results obtained from users. Typically, only one or two users are used for rapid prototyping, and unless they are chosen carefully, it will not be clear to which user population the results can be generalized.

Table 2

Summary of User Acceptance Factors and Recommendations

| General Factor | | Cause | Recommendations |
|---|---|---|---|
| Perceived lack of utility | 1. | Aid lacks utility | Involve user in design<br>Adaptive design<br>Rapid prototyping<br>Test & evaluation |
| | 2. | Aid is not always appropriate | Education about aid's limitations<br>Explanation capability |
| | 3. | Aid requires organizational restructuring | Task & information flow analysis |
| | 4. | Incompatibility of aid's and user's problem representation | Make compatible<br>Explanation capability<br>Involve users in design |
| | 5. | Unfamiliar decision procedures | Involve users in design |
| | 6. | Perception of builders | Demonstration of utility |
| | 7. | Premature demonstration of aid | Break-in period precedes demonstration |
| | 8. | Aid does not speak "green suit" | Involve users in design |
| | 9. | Lack of confidence | Explanation capability<br>Demonstration of utility |
| | 10. | "Aid will go away" | System integration of aid<br>Senior level commitment |
| | 11. | Inadequate training | Pretesting to determine training needs |
| | 12. | Personnel change | On-going training<br>Embedded training<br>Standard interface |
| | 13. | Bad experience with salesmen | Utility demonstration<br>Test and evaluation |
| Damage to user | 14. | Distrust of new technology | Training |
| | 15. | Loss of control over decisions | Explanation capability<br>Training on aid's limitations<br>Override capability |
| | 16. | Damage to skills and expertise | Maintain a backup system |
| | 17. | Damage to career or status | Organization-sanctioned aids |
| | 18. | Increased workload | Workload analysis and task allocation so aids do not make more work |
| | 19. | "Real men do not use keyboards" | Demonstration of utility<br>Top down implementation |

Table 2 (Continued)

Summary of User Acceptance Factors and Recommendations

| General Factor | Cause | Recommendations |
|---|---|---|
| Aid is hard to use | 20. Bad interface design | User involvement in design |
| | 21. Hardware & software incompatibility | Standard user interface with "device drivers" to handle incompatibilities |
| | 22. Aid packages are not integrated | Organizational mechanism common functional standards |

Extensive testing and evaluation of the aid or system in the conceptual, design, prototype, and fielding stages will also ensure that the aid is a useful and reliable tool. Results of the testing can then be used to demonstrate to users that the aid can help them and to increase their confidence in the aid.

2. The aid is not always appropriate.

Even if the aid does provide the type of assistance needed, the user may not be sure that the quality of the aid's output will always match what could have been done unaided. The user may feel that the aid will not be correct or applicable in all situations, but that he does not know enough about the aid to recognize the errors or situations in which the aid results should not be used. A related problem is a perception that novice users will be too accepting of the aid, not be able to evaluate the aid's products, and therefore use it uncritically.

Recommendations. In the development and testing of the aid, special attention should be paid to the limitations and boundaries of the aid and mechanisms for identifying errors. The limitations of the system and identification of errors should be treated explicitly in the training course and in training embedded in the aid. By incorporating an explanation capability in the aid, novice users will become more knowledgeable and not indiscriminately accepting of the aid's results. Algorithms should be well documented.

3. The aid requires organizational restructuring.

Use of the aid may result in a change in information flow and task structure. If these necessitate a major organizational change the aid may not be used. On the other hand, at least some organizational changes will be necessary, and acceptance will depend on the individual organization's flexibility in coping with change.

Recommendations. Builders should attend to existing task and information flow structure and design aids that fit in. As discussed previously automation may change the way decisions are made, and at some point a restructuring of the present military organization may be in order. However, since it is not clear how automation will change the existing organization, such changes will not occur in the near future. Incompatibility with organizational structure will most likely result in scraping the aid.

4. Incompatibility between the aid's representation of the problem and the user's representation.

The system's conceptualization and representation of the decision problem may not look like that with which the user is familiar. It may not seem natural or to fit the problem, or it may not follow the standard operating procedures. This incompatibility may make it difficult or impossible for users to relate their knowledge to the advice presented by the aid. Users may be unable

to provide the judgements needed by the aid because they have not thought about the problem in the terms used by the aid. Because the aid's representation of the problem does not match the users, it is perceived as incorrect.

Recommendations: An explanation of the aid's decision processes in terms familiar to the users may change their perception of the aid. Also the aid's representation of the problem and decision making procedures could be constructed to match the user's, if such a representation does not damage the aid's effectiveness. If the problem is that the user does not understand the aid's algorithm, an adequate explanation of the aid may be enough to create acceptance. To insure compatibility between the system's and users' representation of the problem, users should be incorporated into all phases of the design and development process. Where possible, follow representations of the problem as defined in field manuals and other official publications.

5. Unfamiliar decision procedures.

A related problem is that the aid procedures may seem unfamiliar to the user. They may appear to be unnatural, not to fit the problem, or not to fit into the larger decision making procedures. A variation of this problem is found when different commanders' decision making styles vary, and the aid may not support preferred procedures. The commander may have previously developed a way of thinking in his subordinates and now the aid requires different procedures or a different conceptualization of the problem.

Recommendations: Recommendations made for the previous problem are also applicable here. The problem of different decision making styles might be addressed in an adaptive user interface that adapts the aid to different styles. However, at the present such an adaptive interface is technology limited.

6. Perception of the aid's builders.

Perceived utility is also affected by the user's perception of the aid's builders. Government contractors may be seen as not possessing the required military background to develop a system with utility.

Recommendations: Education about and demonstration of the aid's capabilities will help alleviate this distrust.

7. Premature demonstration of the aid.

A lack of utility may be perceived if the aid is demonstrated during a major exercise, and there was not enough time before the exercise to eliminate the bugs from the system.

Recommendations: Any new system will have a break-in period. If organizational acceptance will be determined by performance in field exercises then the break-in period should precede an exercise. This problem becomes significant

as we develop more prototype systems using adaptive design. The system should be made available to users before the exercise so they can become familiar with it.

A lack of utility may be perceived during the demonstration if users have not had enough training to use the system comfortably and as it was intended to be used. Pretesting could determine how much training is needed to operate the system comfortably, and developers could make sure users have this training prior to the exercises. Training embedded in the aid can reduce the amount of external training needed and is also valuable as a memory support if the aid is not used frequently.

8. The aid does not speak "green suit" or "muddy boot".

The language used, the phrasing, and the knowledge presentation may not be those that are ordinarily used when dealing with the problem. In addition, some jargon is area or command specific. This has implications for Army wide systems or systems that are to have joint service applicability.

Recommendations: An aid should be developed using a Subject Matter Expert (SME) from the user world. A procedure which would address this problem is Adaptive Design. Here SMEs who are interested in developing aids in their area of specialization are trained in decision aid development, and in using software tools that facilitate aid development. (See the conclusion for a more extended discussion of Adaptive Design.) Because the SME is developing the aid he or she will use military language familiar to those who will use the aid. One problem with this approach is that the language may be too specific or too colloquial to be used in other functional areas or commands. However, using military language and representing knowledge in a way that is familiar to the user is a key element in developing user friendly and accepted systems.

9. Lack of confidence in the aid's performance.

Lack of confidence may occur because the system gives a "black box" solution instead of a transparent one. The user does not understand how the system functions, the basis for its recommendations, or the limitations of the aid, and is not able to recognize when the system is in error or its use is inappropriate. That is, the user is responsible for decisions over which he feels he has no control and does not trust the system enough to blindly yield control.

Recommendations. Users should have the option of obtaining an explanation of how the system works. The user should be trained to recognize when the system is in error and when its use is not appropriate. However, the provision of an override capability is problematic because the system may be overriden inappropriately if the user prefers his own biased procedures to those of the aid.

Evaluation data and results of exercises can also help demonstrate the usefulness of the system and increase confidence in the aid.

10. "The aid will go away. Automation is a five year fad."

Unless the aid is part of a standard procedure, it may indeed go away when its "champion", i.e., the person actively advocating the aid's use, moves on to the next assignment. If the aid will go away shortly, then there is little point for users to go through the trouble of learning to use it and of changing their procedures to accommodate it. Similarly, it may be felt that automation in general is only a fad which will go away when it is clear that it is more trouble than it is worth.

Recommendations. If the user's perception that the aid will go away with the champion is correct, then steps are needed to ensure the institutionalization of the aid and to communicate to the user that the organization can and does support the aid. The attitude that "automation is a 5-year fad," can be changed by developing and communicating to users the long range plans for automation. Users will accept the aid if "the old man accepts it", if it is clear that the aid or system has the service's stamp of approval.

This problem is related to a lack of senior level commitment to the aid or system. Commitment can be shown by a statement of expectancies, allocation of staff, funds or training, or an outline of the implementation plans and phasing. Users need to be able to discern what their supervisors real attitudes toward the proposed aid or system are. If inconsistent signals are being sent, users will perceive a lack of commitment and act accordingly. Senior level commitment is a big factor in implementation and acceptance.

11. Inadequate training.

Inadequate training can seriously undermine the success and acceptance of the system. Such training can make the system hard or impossible to use, or it can result in partial or incorrect usage with the result that the system appears to have less utility than it actually has. In this case, the system may not be used because users do not think it will improve their performance.

There are several reasons why training may be incomplete. Developers are not likely to be training experts and may not know how much training is needed to optimize performance on the systems. Or, after training has been completed and the trainer has left, new and unanticipated difficulties arise with which the user is not equipped to deal. Another problem is that the user organization may not want to allocate the time and effort needed for adequate training. The result of such incomplete training is the system will be harder to use, may not be used fully or correctly, and consequently may show less than its full utility. All of these can make the users reluctant to use the aid.

Recommendations. To insure that the training is sufficient and at the appropriate level, the vendor's training package should be pretested using intended users. The developer should also make available training and consultations on a continuing basis, not just a one shot set of instruction classes. A "hot line" to the trainer would provide help with unexpected problems after training is completed. A resident champion or master user, who advocates and

is knowledgeable about the use of the system, could also provide the needed on-going instructional support in addition to formal vendor training. A technique with great potential for improving the cost effectiveness and availability of training is embedded training. In embedded training, training and help in the use of the aid is provided as part of the aid software. Use of embedded training does not avoid the problem of identifying the intended user and designing effective instruction for him or her. In fact, the importance of these factors may be magnified because the instructor is not available to answer unanticipated questions or compensate for a poorly designed instructional program.

12. Personnel change.

New users are constantly coming in with the rotation of Army personnel. These users have to be trained, and often training is accomplished by passing it on from user to user. This method of training is not necessarily bad but could result in the gradual degradation in the quality of the training. Further, user acceptance is then an on-going problem because each new set of users must be convinced to use the aid.

Recommendations. On-going vendor training and support, computer assisted instruction (CAI) embedded in the system, and very user friendly interfaces would minimize the problem. At a broader level, it will be necessary to include Integrated Logistics Support (ILS) plans along with the development of decision aids themselves. This is especially important as decision aiding moves from the research environment to the operational world.

Another solution that partially addresses the problem of rapid turnover of users is to have a standard, common interface within services and across service systems. Any system to which the user was transferred would use the same interface to the aids. He could still need training in specific aids but much of the access procedures, software tools, and software sets would be the same no matter where in the Army he went. For example, there could be a common data file format and standard procedures for using the data file no matter which data file was used.

13. Bad experiences with salesmen.

The user's expectations of what the system will do may be too great and he then rejects the aid as lacking in utility when actual performance falls short of his expectations. In order to obtain a contract or have the system implemented, the contractor or developer may have exaggerated the aid's expected performance, minimized its limitations, or passed over its disadvantages, training requirements, and problems. Part of this problem may be because the builder may not have an accurate picture of the aid himself. This in turn stems from inadequate evaluation and testing of the system. If the user has had bad experiences with salesmen in the past where the capabilities of the aid have been misrepresented, the user may be distrustful of the claimed capabilities of future aids. If he has been burned once, he may be unwilling to accept

future aids. On the other hand, designers complain that aids do not sell without "bells and whistles". Aids that can be implemented with current technology are not exciting enough for users who may be looking for an aid that addresses important problems which are obviously hard to solve.

Part of the gap between what user's expect from the system and the capability of the system may stem from differences between the user's and builder's time frames. Builders focus on the future not the present, and describe an aid developed with a technology ten years in the future. The customer or user thinks the builder is describing an aid for the here and now. This problem may be due in part to the acquisition process as it is practiced historically. The length of the acquisition cycle guarantees obsolescence for many aids, and to circumvent this the designer may project the technology he thinks will be available when the aid is ready to be prototyped. If he guesses wrong, the needed technology will not be there to develop the aid as originally described.

Recommendations. Adaptive design would bypass the lengthy acquisition process. The user-developer knows exactly what the aid can or cannot do and do not have false expectations for the aid. Another recommendation is adequate evaluation and testing so that the salesman knows the aid's capabilities, likely problems and required level of training. A military champion responsible for implementation of an aid could monitor contractors' claims for the aids. Adequate training should be supplied so that full capabilities of the aid are demonstrated and expectations are not unrealized because of lack of training. All personnel -the developer, builder, and user- need to be aware that there will be "burn in" problems with a new system and that the system should not be judged prematurely.

Damage to the User

People see computers as affecting their sense of self, jobs, skills, politics, and organizational relationships. Sometimes these perceptions are justified, sometimes not. If the perceived potential damages are too great, users will not accept or use the system.

14. Distrust of new technology.

Distrust of technology could be computer anxiety, or fear of the unknown. The jargon used in the aid may be different from military jargon suggesting that the developer was not military and does not really know the combat situation. The new system brings new equipment to learn to use and service. The user may be afraid he would not be able to use the system "correctly" and will appear unintelligent.

Recommendations. This problem may go away as automation becomes part of the normal operating procedures in the services. One recommendation is to use computers even more extensively in officer education and training than they are presently.

15. Loss of control over the decision making process.

The user has ultimate responsibility for decisions. Because no aid can resolve all problems or be perfectly reliable, the user cannot turn the system loose and blindly accept any and all recommendations. Users are then justifiably reluctant to accept a system over which they have no control. Loss of control is also related to another factor - concern over decrease in personal power.

Recommendations. Decrease in personal power and concern over an inability to control decision quality can be addressed by building into the aid an override system where the user can substitute his own judgement for any or all parts of the aid processes. However, overrides may not always be desirable, for example, in cases where biases or preferred procedures lead the user to suboptimal results. The aiding algorithm should also be transparent or explanation of the aid results available. In cases where the aiding operations cannot be easily explained, such as mathematical algorithms, higher level or more intuitive explanations can be supplied. As discussed previously the explanations should be in terms of a language and concepts that are compatible with the user's usual way of thinking about the problem. Training, either formal or embedded, should supply the user with a list of limitations of the system or situations where its use is not appropriate. Loss of control over decision quality can also be addressed by creating trust in system output. If the user can be shown by means of experience with the aid, evaluation results, demonstrations, or the endorsement of those in authority that the aid can be trusted, then the user is likely to trust and accept it.

16. Damage to skills and expertise.

If the decision maker's skills and expertise have been incorporated into the aid and used in place of the decision maker, then over time these skills and expertise may erode if they are no longer used. The experience base which was the foundation of the DM's expertise may disappear. This in turn may lead to excessive dependence on the aid, where, if it breaks down, adequate manual skills would not exist to take over. The seriousness of this problem depends on the stage of decision making that is aided. If it is an information aggregation stage or information storage stage, it may not matter. Or if it is a step decision makers do not do well anyway little is lost. However, if the skills that are aided are those developed through long experience, loss of this expertise can be serious. Loss of skills also depend on who will use the aid. If it is intended for novices, few skills will be lost. If it is intended for experts, the potential for loss of expertise is greater. As such, this problem is especially relevant to the development of expert systems.

Recommendations. Skill maintenance and practice using a back up system can keep expertise from being lost. It is likely that DSS in the near future will not automate all the decision making steps, with a ready made decision coming being produced. Rather they will aid specific and limited steps within the decision cycle. This may mean that the decision making procedures will change and the nature of the user expertise involved will also change. An analogous

situation existed in the 1950's when it became possible to computerize statistical analyses in the social sciences. Raw data was fed into the computer and a series of parameters and statistics came out. Some researchers were uncomfortable with this because they liked to work with the raw data and to get the "feel" of it. However, they learned they didn't need to look at the raw data and that they could do their analyses faster and better using only the computer generated parameters. With the computer more sophisticated analyses were possible. Similarly, with the incorporation of automated assistance into the decision making cycle, although the nature of decision making expertise may change, the need for human experts will not vanish. However, it is important that automated environments continue to provide contexts in which such expertise can be developed. The decision maker must not become just a decision aid operator.

17. Damage to career or status.

The user may fear that with the loss of the skills and expertise that make him valued and unique will come also a loss of status. Or he may feel that because the computer now contains his expertise, he is not as essential as before. He may feel that the computer will take over his functions, there will be an erosion of his responsibilities and he will eventually be replaced, or down graded. If he cannot exercise his skills and expertise, the user's job satisfaction may be decreased. He may feel he will make a wrong decision because he does not understand how the system functions, or that he is responsible for the quality of the decision but does not have control over it. The user may fear that more will be expected of him because a tool is now available to do part of his work.

Another perception of threat to career may arise from the prospect of having to learn new systems and new skills and the uncertainty of how he will function in this new environment.

On the other hand, the user may think the use of aids that are not a part of the standard procedures could also damage his career. Personnel are rewarded for staying within the system, and use of an aid not officially sanctioned may result in damage to his career.

Recommendations. Part of the fear of learning new skills is a training problem. The training should be approached on several levels: schoolhouse, embedded training, and training using realistic simulations or an operational setting. Part is also a design problem in that the system should be as easy to learn and use as possible.

The problem of responsibility for decisions the user feels he has no control over can be addressed by making the system transparent so the user knows the origins of the computer output and can decide whether or not to use this output.

Another part of the problem is the proliferation of aids developed outside the organization. Mechanisms are needed to integrate new aids so that the user is not put in a position of using aids not organizationally sanctioned.

18. Increase in workload.

Workshop participants thought that staff officers are overworked now and use of the aid may only add more work. Use of the system may involve different or more cognitive skills, and the workload of the user may be increased not decreased. The computer may take over much of the routine work involved in decision making leaving the more difficult tasks for the user. Users may have more information to process, have to learn about entirely new systems, or have to integrate information from multiple decision aids. The new system brings an increased workload and greater responsibilities. The user may now be responsible for faster and higher quality decisions. In addition, users complain that they need to maintain manual back up systems in case something happens to the computer and they must therefore maintain two systems, which doubles the amount of work.

Recommendations. Objections to aids due to workload are partly a matter of inaccurate expectations. It should be emphasized to the user that the savings achieved with the aids is not work but time and/or decision quality. Field exercises testing the aid should also include the practice of back up systems so that it is clear that the maintenance of back up systems is part of the new procedure. Demonstrations can make clear just what are the relative advantages of the aid. Users should be prepared for the change in work composition, initial work slow down and possibly added workload. The focus should be on increased effectiveness, not on an easier job. On the other hand, builders should conduct workload analyses so that if the workload has in fact increased, the design can be reconsidered.

19. "Real men don't use keyboards."

Keyboards are traditionally associated with clerks and not with a masculine combat environment. The officers for whom the aid was designed may feel that interacting with a keyboard is not appropriate for their ranks. Not all Workshop participants thought this factor was a problem for user acceptance or even that it represents user attitudes. Moreover, this is an attitude that may not be a problem in the future as more computers are put in the field and users become more comfortable with them. Some officer schools furnish students with computers which they are expected to use in doing their assignments.

Recommendations. Implementation should start at the top, so that the commander understands what the aid can and should do and will convey his expectations to the staff officer for work at least as good as the aid will support. Incorporate the aiding system into the school system so that users can become comfortable with computer technology and with specific systems.

For those officers already in the field, demonstrations clearly showing the advantages of using the system will help to override reluctance to use keyboards. Even more effective in changing present officers' attitudes may be the observation of the improved efficiency of new officers using their computers.

Aid is Hard to Use

An aid could have a great deal of utility, but if the user cannot use it, can use it with difficulty, or can only use it in a limited way, it may not be accepted by the user. That is, the aid has utility but the user cannot access this utility. Items 20 to 22 discuss reasons why an aid may be hard to use.

20. Bad interface design.

The design of the user-computer interface could make it difficult for the user to get the computer to do what he or she wants it to do. For example some types of commands are hard to remember.

Recommendations: Human factors considerations should be planned for in the design stage and should be evaluated early enough so there is still time to make substantive changes in the interface design. Human factor guidelines and standards are available to guide the interface design. However, guidelines are sometimes too general or too specific for a particular system. Rapid prototyping is a good way to try out and test different interface configurations.

21. Hardware and software incompatibility.

If the aid is not compatible with existing hardware and software, the aid is not likely to be used. There are a number of reasons why it might not be compatible. Development and modification of the aid might be easier using one set of software. For example, an SME developing an aid using adaptive design may tend to use an expert system (ES) tool with which he or she is familiar and which he or she considers easy to use. The SME may feel he or she will address compatibility problems after the aid is developed. In addition, military software and hardware standards may change. Builders may try to predict what future standards will be and guess wrong. Military "standards" are not consistent throughout the Army, or between services and it is not always clear which set of standards to use. With new technology developments, last year's standards may no longer be appropriate.

Recommendations. A layered approach to system design should be adopted to minimize the inevitable hardware incompatibilities. The user interface layer should be standard, the aid itself should be machine independent, and the interaction between the aiding software and the hardware should be handled by "device drivers". These drivers are software links between the aid and existing system hardware that can transform the aid hardware requirements into requirements compatible with existing system hardware.

22. Aids are not integratable and integrated.

There are two aspects to this integration problem: (1) Aids are not integrated into the day to day operations of the organization. At the present there is no formal mechanism for getting isolated aids developed and integrated into the large organization's standard operating procedures. (2) Aids are not integratable. Isolated aids are being developed where each addresses part of a larger problem, but these aids don't fit together or talk to each other. Each aid executes a subtask of a larger problem, but the aids, having been developed by different SME's or contractors may use a different conceptualization or representation of the problem. One aid's output may not be able to feed directly into the aid addressing the next subproblem. Finally, if each aid has a different interface, the user is faced with an impossible task of learning different interface conventions and switching between them.

Recommendations. A common set of functional or mil standards like those that define the 1553 Data Bus is a preliminary requirement for aids that work together or "talk to each other." It is also a primary prerequisite for getting aids integrated into the organization. The problem of getting isolated aids integrated is a management problem that needs to be addressed.

## INVOLVING THE USER IN AID DESIGN AND TESTING

Many of the recommendations in the previous section suggest involving the user in the design and evaluation of the aid. Figure 1 shows the rationale underlying the recommendation to involve users in aid design and development. If users are involved, designers can more validly assess user requirements and potential difficulties with the system. Users will have a better understanding of the system and will be more committed to the system design if they have helped to design it. These three factors - a better understanding of the system, a better system, and commitment to the system - lead to increased use and satisfaction with the system. The evidence is not clear whether increased use causes increased satisfaction or vice versa, but there is probably an interactive effect. In any case, user involvement should lead to increased use.

However, user involvement is often not easy to implement. This section will discuss some of the problems associated with obtaining users and makes recommendations for addressing these problems.

1. Potential military users are busy people who are overworked now, and often engaged in projects from which they cannot be spared. If they are assigned to assist aid designers it may mean extra work for them or for their colleagues. Assisting aid designers adds another job to an already impossible schedule.

Recommendations. Allocation of personnel and time for user assignment to aid designers should be built into short and long term military planning cycles. User involvement should be part of the activity's workload. Top level assignment would facilitate user involvement. Use of adaptive design, where the aid is developed by the end user, would also address the problem of finding users to aid the design process.

Another recommendation is to co-locate the designer/analyst in the user's environment. User's would not have to be pulled off of their regular work and the designer could observe the users in their usual work environments. This method of involving users has been implemented successfully in private industry, but has the potential for disrupting user performance.

2. The section defining the user discussed the point that tomorrow's complex decision support and information systems will be used by users that vary in functional area, service, experience, and a wide variety of individual characteristics. This means that if only one or two users can be provided to assist aid design and evaluation, then it is not clear which users to select and to which users the results can be generalized.

Recommendations. Draw users from several environments. Select users based on what type of information is needed for design or evaluation. Research is needed to determine which individual differences impact requirements and acceptance.

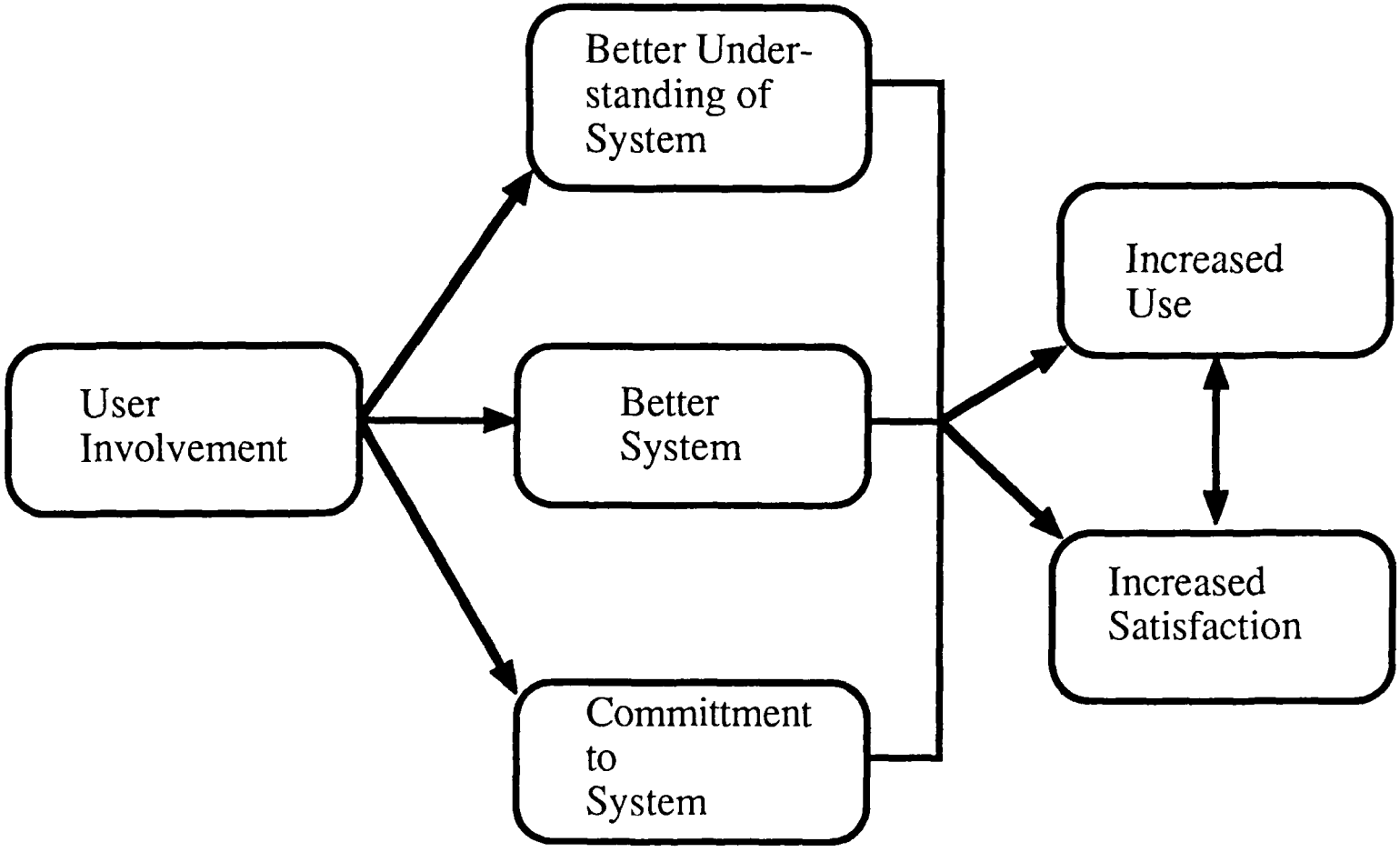


Figure 1. Why involve users?

3. Users may be reluctant to participate in an aid design, especially if it is an expert system. This may be because the user is protective of his own expertise, because of a skepticism that a micro-chip could do what he, the expert, does, or because the user fears that a detailed examination of his expertise may expose its flaws.

Recommendations. Involve multiple SMEs so that the effect of individual flaws will be minimized, and a SME won't feel he has sole responsibility for providing the expertise that will be built into the system.

4. Ideally, users should be involved in the design and evaluation of the aid over the life cycle of it development and fielding. However, it is unlikely that a user would be assigned on a long time basis. Other projects and organizations are always competing for the user's time and involvement. Even if he were so assigned, the rotation system in the services limits the length of involvement, and breaks the commitment-interest continuum of the user. Expert systems especially require a long user commitment and management may be unwilling to release them for the months or even years the design and testing require.

Recommendations. The use of rapid prototyping can help minimize the time required for design and evaluation and consequently for users' services. In adaptive design the user/designer takes the developing aid with him to new assignments and the time required to develop the aid is not a problem.

The use of different users over the design and evaluation cycle is actually desirable. It ensures that the aid will have utility for and be usable by the whole class of intended users and cancels any effects of personal idiosyncrasies of individuals involved in design and evaluation.

High level assignment of users to design and evaluation duty will minimize the importance of the personal interest-commitment factor in securing user cooperation. High level assignment would also be necessary for obtaining the long term services of experts for ES development.

## ORGANIZATIONAL SUPPORT

### Links Between the User, Builder, and Developer

Figure 2 describes links between the various participants in aid design, development and implementation. Included are those who will actually use the aid, i.e., the end user, the decision maker, and the organizational user. The builder designs, constructs and evaluates the aid. The user provides information to the builder for requirements analyses and for test and evaluation. The developer is responsible for aid development and sets in motion and oversees aid design, construction and evaluation by the builder. The developer obtains users for the builder for requirements definition and evaluation. The developer also provides opportunities for field testing the aid by the builder and deals with the intended user organization to get the aid incorporated into the organizational structure.

The change agent or champion is an individual within the organization who enthusiastically promotes the aid, can point out the aid's utility and can help in training or trouble shooting problems with the aid. The champion's perceived power and authority are important to whether the aid is accepted. The change agent has links to the developer, organization, and user.

Except for the builder-developer relationship, the links between the participants are usually informal and unstructured. However, bridging the gaps between the participants is critical to both user acceptance and getting the aid fielded. The user-builder link is especially problematic. Anything that can be done to strengthen and formalize the links will promote acceptance of the aid involved.

In adaptive design, the builder, change agent and user may be the same person. An SME learns the technology involved in developing an aid. He identifies a task that needs aiding within his area of expertise, and determines the task and knowledge requirements to be built into the aid. The SME designs, tests, and modifies the aid and uses and promotes the aid to others and within the organization. Because the SME assumes many roles otherwise performed by diverse elements communication and acceptance are enhanced. In adaptive design a big stumbling block is the weak link between the SME/builder/user and the organization. Generally there is no formal link for integrating the work of the SME into the organization. Without such a link wide spread organizational acceptance of the aid is unlikely. Adaptive design can address many of the factors that promote user acceptance. However, before it can be truly feasible as a design strategy, some mechanism must be created for institutionalizing the aid and getting it in place as part of the organizational structure.

A methodology that provides for close communication between the user and builder is rapid prototyping. A critical factor in user acceptance is that the system must address a perceived need and support improved performance. This

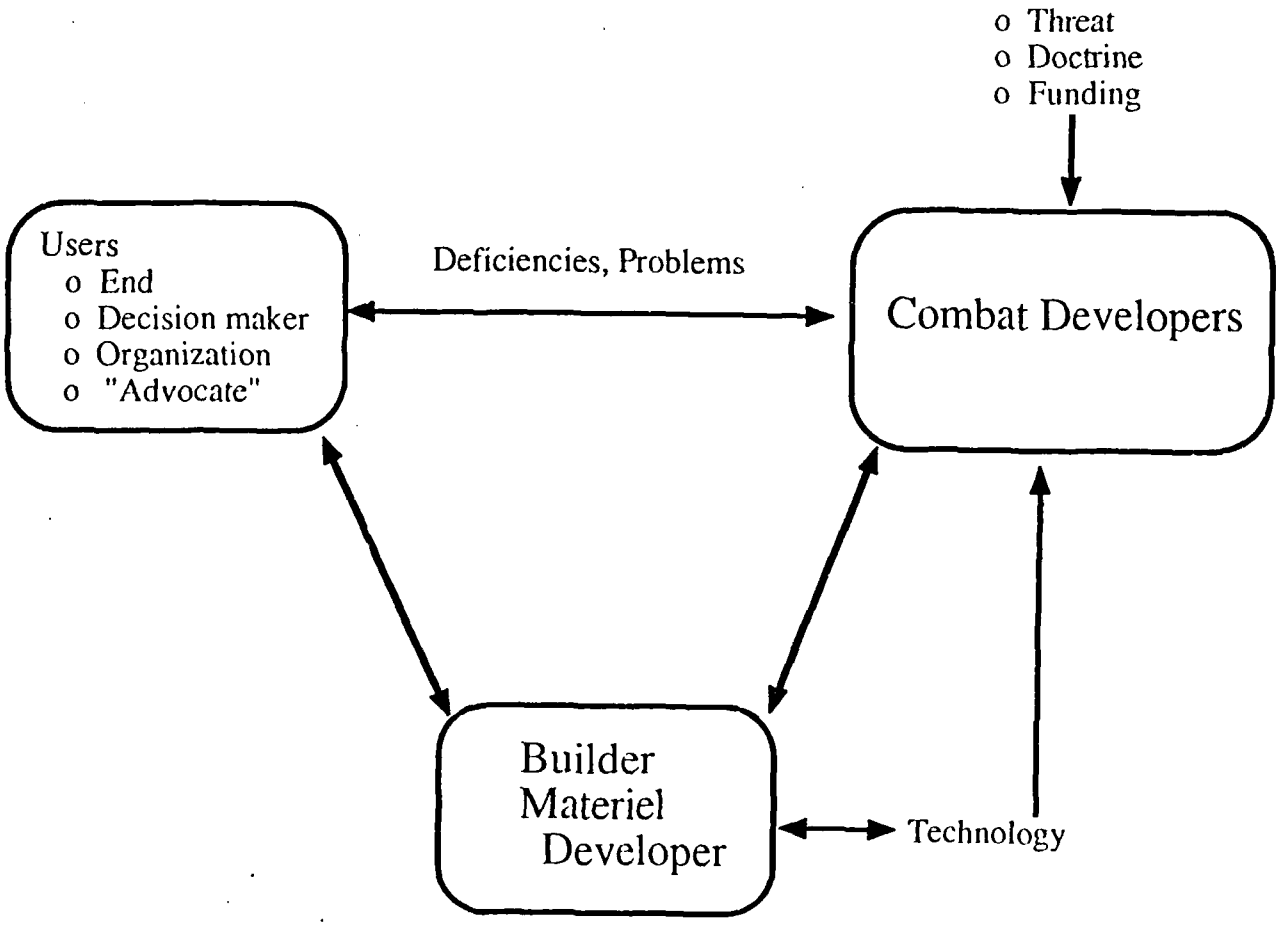


Figure 2. Linkages between participants in aid design, development, and implementation.

is a requirements definition problem. However, it is not enough to ask users what they want. Often they cannot verbalize what they need but will "know it when they see it", or the system may change task procedures so that some requirements cannot be predicted in advance. Traditionally, user requirements are defined at the beginning of the material development cycle and no provisions are made for substantial modifications to those requirements. Thus, traditional methods for defining and validating user requirements are inadequate for DSS development. Rapid prototyping is a technique that supports the rapid development of successive versions of the aid, which users can then test and evaluate. Aids can then be quickly modified based on user requirements and tested again by the user. This methodology provides close user-builder communication, the opportunity for the user to test the aid while his input can still substantially influence the design, and a mechanism for users to react to operable real time simulations. All of these factors will promote improved requirements specifications and user acceptance of the aid.

There are a number of ways the links between these various groups can be strengthened:

- Develop formal organization structures to establish these links and facilitate communications between them.
- Identify an aid champion, i.e. a single individual or small group who is committed to the aid implementation, understands it, can oversee user training and trouble shoot the break-in period. The champion is a self selected military individual who has a personal interest in the aid and can interface with the other groups.
- Adaptive design is especially conducive to developing an aid champion, but this procedure must have organizational support.
- Rapid prototyping supports the close interaction between user and designer.
- Form small multi-agency groups that can operationalize and promote informal linkages.

## Organizational Mechanisms

With respect to organizational structure, mechanisms are needed that will:

- Identify and provide users for requirements specification and evaluation in an on-going and systematic fashion.
- Define requirements.
- Be responsible for the timely testing and aid modification.

- Set functional requirements to ensure compatibility between aids and systems.

- Assist in the identification of which problems to aid. Actual and perceived utility of the aid is one of the most important factors in user acceptance. The Army, for example, has not stated for which of its problems decision aids are needed. A related problem is how to write a description of a decision aid to be put in a required operations capability (ROC) document. One solution is the observation of simulation exercises of staffs.

- Promote communication between the users, builders, and developers.

## RECOMMENDATIONS

The recommendations that were made in the preceding sections are listed in this section.

User Involvement:

Identify and involve the intended users in aid design, development, and evaluation.

Design Principles:

1. Make aid's representation of the problem match that of the users.
2. Incorporate an explanation capability in the aid.
3. Document and explain any algorithms and the aid's logic.
4. Consider the place of the aid in the existing task and information flow. Aid should fit in existing organizational structure.
5. Consider human factors principles in the aid design. Test and evaluate for ease of use.
6. Incorporate a common interface across aids and systems.

Design and Implementation Procedures:

1. Use evolutionary requirements analysis and design.
2. Use adaptive design and rapid prototyping strategies to circumvent many of the problem of an up-front requirements analysis.
3. Do ongoing test and evaluation in the design, prototype and fielding stages.
4. Provide break-in period for aid before major field exercises which test the aid.
5. Demonstrate aid's capabilities to users.
6. Do a workload analysis so aid does not increase workload.
7. Give adequate training in the use of the aid so that full benefit can be obtained from the aid. Pretest the training package. Give training on the limitations and boundaries of the aid.
8. Use embedded training and built-in help facilities.

Organizational Support:

1. Include allocation of users for test and evaluation as part of large and short term planning.

2. Seek public organizational commitment to the aid.

3. Create formal or informal organizational structures to establish links between the user, builder, and developer and to facilitate communication between them.

## CONCLUSIONS

Several general recommendations underlie most of the recommendations mentioned earlier. These are: (1) involving the user, (2) sufficient user training, (3) evolutionary requirements analysis, and (4) careful organizational management. Each of these is discussed below.

1. Involve the user.

Involve the user in aid design and evaluation. User involvement promotes commitment to the aid, aid utility, ease of use, a better user understanding of the system, and ensures the language and problem representation will be compatible with the user's. All of these are factors that affect user acceptance. Organizational support is critical in identifying appropriate users and obtaining cooperation of the users.

2. Sufficient user training.

Training was thought to have a significant impact on user acceptance and system usage by affecting both ease of use and perceived utility. All users should receive training until they are comfortable with the system. Training could include formal classes, a hot line, manuals, embedded training, and ongoing vendor support as well as more general training in the use of computers. Training implications should be considered during design and development. A good design can minimize the amount of training that is needed.

3. Evolutionary requirements analysis.

A critical factor in user acceptance is that the system must address a perceived need and support improved performance. This is a requirements definition problem. However, it is not enough to ask users what they want. Often they cannot verbalize what they need but will "know it when they see it." Or the system changes task procedures so that some requirements cannot be predicted in advance. This means that requirements often cannot be specified "up front" and that the development of aids does not fit well into the materiel acquisition process of the Services. In traditional acquisition, requirements are established up front, prior to design and development. Test and evaluation results only in fixes to the existing system. However, often requirements evolve as the aid is being developed. Two procedures that address the requirements definition problems are adaptive design and rapid prototyping.

Adaptive design. Many of the problems in user acceptance can be addressed by using a SME to develop the aid in an iterative fashion. The SME-developer is then the source of the aid requirements. This method is being used by the Army Signal Center, the Air Force Institute of Technology, and the Naval Postgraduate School. A key problem with this method is that there is no formal mechanism to get the aids integrated into the user organization, and if this method is to be made feasible, this problem must be addressed at the organization level.

Rapid Prototyping. This is a technique which supports the rapid development of successive versions of the aid, and which users can then test and evaluate. Aids can then be quickly modified based on user requirements and tested again by the user. This iterative approach provides for close user-designer communication, the opportunity for the user to evaluate the aid as it is developed when his input can still substantially influence the design, and a mechanism for users to react to operable real time simulations. All of these factors will promote improved requirements specifications and user acceptance of the aid.

4. Careful organizational management.

Most of the recommendations discussed in this report can best be accomplished through careful organizational management of the selection, design, and implementation of the aid or DSS. For example, utility can be maximized through systematic requirements analysis, on-going and timely test and evaluation, and integration of the aid into the larger organizational structure. One participant suggested that all of the responsibility for user acceptance depends on how the organization approaches the selection, design, and implementation of an aid.

The organization should:

- Ensure ongoing and reliable user availability for requirements analyses, and test and evaluation.

- Develop and employ a Life Cycle Development process that accommodates an interactive requirements analysis, e.g., rapid prototyping.

- Provide public commitment to the implementation of aids that are selected.

- Develop mechanisms which will provide for formal links between the user, developer, and builder.

The problem of user acceptance is a complicated one, not ultimately solved with quick and easy cosmetic fixes. The solutions lie in aids that both actually and apparently respond to real needs of the users and in an organizational structure that can facilitate and formalize the links between the user, combat developer, and builder.

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Appendix A

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